**USING CHEMICAL THERMODYNAMICS  
IN ENGINE ENERGY BALANCE ANALYSIS**

Follow these steps to use heat of reaction concepts in your analysis of engine energy balance analysis…

**PROBLEM:** A 3.0 liter 4-stroke SI engine is run on ethanol (C2H5OH). For better emissions, the engine is run at an equivalence ratio of 0.75. The air and fuel enter at 25 C and 1 atm. The exhaust is at 727 C. In this situation, 320 MJ/kmolfuel leaves the engine via the cooling system. Assume 100% combustion efficiency and products consisting of only CO2, H2O, O2, and N2.  
 **a) Find the specific work output of the engine in MJ/kmolfuel.**- compute the excess air coefficient and write the reaction equation  
- determine the LHV of ethanol based on reactants and products at STP  
 *=> use tabulated data from heat of reaction activity* (note that this is independent of equivalence ratio)   
- determine the heat of reaction based on reactants at STP and products at the exhaust temperature   
 *=> use tabulated data from heat of reaction activity* (note that this depends on the equivalence ratio)  
- the difference between these represents the cooling system heat rejection plus the specific work  
  
**b) Find the percent of fuel energy that leaves the engine via the cooling system, via specific work, and via sensible heat carried away in the exhaust.**- draw a diagram that relates the incoming fuel/air energy and these three exiting streams  
- express these as a percentage of the LHV  
- use the 1st law to find the sensible heat carried away in the exhaust  
- recognize that the specific work percentage is the arbitrary efficiency of the engine  
  
**c) Under highway driving conditions, the part throttle volumetric efficiency is 70% and the engine speed is 2000 RPM. Estimate the power output of the engine under these conditions.**- write the long equation for brake power output  
- find the F/A ratio on a mass basis at the specified equivalence ratio  
- express the heating value on a MJ/kg basis  
- express the engine speed in proper units (rev/sec)  
- assume an inlet air density  
- use known engine geometry data  
- apply the arbitrary efficiency value found above  
- calculate the brake power output with the given volumetric efficiency